to fund the full request in fiscal year 1983 would not require following the new plan to equip all carriers with F-14s; the Congress could decide to terminate F-14 procurement at a later date.

The Congress has been faced with the F/A-18 program for several years. By fiscal year 1983, about one-third of the estimated cost of the total program will have been appropriated to develop and produce 157 of the planned 1,366 airplanes. This argues against outright cancellation of the program, but it is not yet clear what part the F/A-18 will ultimately play in the Navy's force structure. The Congress will have to decide whether it concurs with the view that the F/A-18 is a suitable fighter for the Marine Corps but not for the Navy, and also whether to fund the procurement of the F/A-18 as the Navy's new light-attack aircraft replacing the A-7E.

SCOPE OF THE PAPER

This paper does not directly address the issue of the value of expanding the Navy by two carriers and two air wings. It does, however, present the cost of adding air wings. It also analyzes the costs associated with the Navy's plan to modernize fighter and attack squadrons, and compares possible alternatives.

Chapter II addresses the total costs of the Navy's plan to add two air wings and to replace all remaining F-4s with F-14s and all A-7Es with F/A-18s. Chapter III analyzes alternative approaches to modernization.

CHAPTER II. THE COSTS OF THE NAVY'S EXPANSION AND MODERNIZATION PLAN

This chapter presents the costs of the Navy's plan to create two new carrier air wings, replace all remaining F-4s with F-14s, and replace all A-7Es with F/A-18s. It then briefly examines the Administration's five-year plan for procurement of naval aircraft. All costs are in 1983 dollars unless otherwise specified.

LONG-RUN COSTS OF EXPANSION AND MODERNIZATION

The total procurement cost of the Navy's plan would be $30 billion in 1983 dollars. This includes the cost of aircraft placed in the squadrons, of aircraft added to training squadrons and the repair pipeline, and of aircraft purchased in advance to replace peacetime losses for 15 years. About 40 percent of the amount would pay for the two additional carrier wings, while the remainder would pay for modernizing the existing wings.

Cost of Additional Air Wings

Each new wing would cost $5.6 billion in procurement and add about $200 million per year in operating costs. This estimate assumes procurement of the Navy's most modern types of aircraft, including F-14 fighters and F/A-18 light-attack aircraft. It also assumes that the S-3 production line would be reopened and that the SH-60 helicopter would replace of the SH-3. 1/

The composition of a new air wing is shown in Table 2. Table 3 itemizes the procurement and operating costs for each new air wing. The methodology used in generating these figures is described in Appendix B. The aircraft for each wing, plus the additional aircraft required for the Fleet Replenishment Squadrons (training squadrons) and the repair pipeline, would cost about $4.2 billion. If only these aircraft were bought, however,

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1/ The S-3 line was closed with provision to reopen, and the tooling put into storage.

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TABLE 2. COMPOSITION OF AN EXPANSION AIR WING

Aircraft Type	Aircraft	Number
Medium Attack	A-6E	10
Light Attack	F/A-18	24
Fighter	F-14	24 a/
Airborne Early Warning	E-2C	4
Electronic Warfare	EA-6B	4
Tanker	KA-6D	4
Antisubmarine Warfare	S-3A	10
Antisubmarine Warfare Helicopter	SH-60	6
Total		86

a/ Including three with the Tactical Airborne Reconnaissance Pod System (TARPS).

these initial inventories would decrease as operations began and aircraft were lost during peacetime operations. In order to maintain inventories, additional aircraft must be procured either in advance or at some rate that keeps pace with anticipated peacetime attrition. 2/ The most economical approach is to buy them in advance at the same production rates as active inventory aircraft; that is what is assumed here. Therefore, Table 3 assumes that the unit cost of the attrition aircraft is the same

2/ Aircraft cannot be procured as the need arises because the entire process of budget request, appropriation, and construction would take several years.

TABLE 3. COSTS OF PROCURING AND OPERATING ONE CARRIER AIR WING (In millions of fiscal year 1983 dollars)

Aircraft	Long-Run Procurement: Excluding attrition aircraft	Long-Run Procurement: Including attrition aircraft for 15 years	Average Yearly Attrition	Total Yearly Operating Costs
A-6E	454	555	6.7	34 a/
F/A-18	585	852	17.8	44
F-14	1,559	2,235	45.1	46
E-2C	377	400	1.5	12
EA-6B	328	510	12.1	16
KA-6D	172	222	3.3	-- a/
S-3A	607	712	7.0	27
SH-60	107	152	3.0	23
Total	4,194	5,643	96.4	202

SOURCE: See Appendix B.

a/ KA-6D operating costs are included in the A-6E total.

as that of the other aircraft. If attrition aircraft were procured each year at the rate at which aircraft were lost in service, the procurement rates would be lower and the unit costs would be higher than those assumed here. The table includes the cost of attrition aircraft for 15 years. This period is somewhat arbitrary; it is the service life of the F-14 and F/A-18, although the other aircraft in the table have longer service lives.

An Alternative Division of Costs. An alternative way of calculating costs would be to include the costs of attrition aircraft in the average yearly operating costs. Viewing the costs in this manner avoids the need to assume a specific length of time for which attrition aircraft should be procured. If no aircraft were initially bought in anticipation of attrition, the total cost of equipping one wing would be $4.2 billion,

and operating costs would then average about $300 million per year, about one-third of which would be average annual costs for attrition aircraft.

Reopening the S-3 Production Line. The totals described above include procurement of additional S-3A antisubmarine warfare (ASW) aircraft. The S-3 production line is now closed, however, and reopening it does not appear in either the budget or the Administration's five-year plan. If more S-3s were not built, carriers could be equipped by redistributing existing inventories of S-3A aircraft, reducing the number per air wing. This would reduce the initial procurement cost of each new wing by $0.6 billion, and the average annual attrition cost by $7 million. Continued peacetime attrition would then require continuous downward adjustments in operating levels until operations became impractical.

Costs of Modernization Alone

Fighters. Adding six more F-14 squadrons to the existing air wings would require the procurement of 155 additional F-14s. This number includes aircraft for the six squadrons, additions to the Fleet Replenishment Squadrons and repair pipeline, and attrition for 15 years. At current rates of production, these airplanes would cost $6.7 billion. The number of active F-14 squadrons (including those in the new wings) would increase gradually over time. When the first squadron had been in operation for 15 years, the last would be five to ten years old. Buying attrition aircraft for 15 years for the entire force would therefore actually allow the force to operate somewhat longer than 15 years, since it would be at less than full strength for the first several years, and would therefore lose aircraft at a slower rate during those years.

Light-Attack Aircraft. Replacing the 24 existing A-7E squadrons with F/A-18 squadrons would require 594 airplanes, including advance attrition aircraft for the entire force. If these aircraft were charged at the average estimated unit cost of the entire 1,209 F/A-18s remaining to be procured, they would cost $11.9 billion. 3/

3/ The total number of F/A-18s to be procured is 1,366; of that number, 157 have been appropriated through 1982.

TABLE 4. ADMINISTRATION REQUEST FOR CARRIER AIRCRAFT PROCUREMENT (By fiscal year)

Aircraft	1983	1984	1985	1986	1987
A-6E	8	8	12	12	12
F/A-18	84	96	108	132	132
F-14	24	30	30	30	30
E-2C	6	6	6	6	6
EA-6B	6	6	6	6	6
SH-60	--	--	--	64	64

FIVE-YEAR COSTS

Over the next five years, the Navy plans to procure 936 aircraft of types deployed on aircraft carriers at a total cost of $26 billion (see Tables 4 and 5). This sum does not include the full costs of the expansion and modernization plan, nor the yearly costs of that plan, nor the Navy's complete expenditure for aircraft over five years, for the following reasons:

- The expansion and modernization will take more than five years;
- Some of these aircraft are also being procured for other purposes;
- Those aircraft that are being procured for expansion and modernization cannot be separated from those that are for other purposes; and
- The Navy will also buy types of aircraft that will not be deployed on carriers.

During these five years, the Navy will also purchase P-3C land-based patrol aircraft, helicopters for deployment on surface combatants, AV-8B Harriers for the Marine Corps, C-9 transports, and other aircraft not included in the tables. Some of the aircraft, such as the A-6E, the EA-6B, and the E-2C, are also being procured to fill shortfalls in existing inventories. Some, such as the A-6E and the F/A-18, are also being procured for the

TABLE 5. COSTS OF CARRIER AIRCRAFT PROCUREMENT (By fiscal year, in millions of 1983 dollars)

Aircraft	1983	1984	1985	1986	1987
A-6E	271	271	320	320	320
F/A-18	2,429	2,358	2,468	2,800	2,800
F-14	1,157	1,300	1,300	1,300	1,300
E-2C	323	323	323	323	323
EA-6B	328	328	328	328	328
SH-60B	--	--	--	858	858

Marine Corps. There is no way of determining which of the aircraft being procured each year are for expansion and modernization, or what the procurement rates would be in the absence of expansion and modernization. Aircraft are procured to support inventory objectives and are assigned as needed. For example, the aircraft for the wing to be established in 1983 would be taken from other parts of the inventory (training, inactive inventory, and so on), while actual procurement would be directed to keeping the inventory at authorized levels. Thus, the airplanes for the new wing do not appear explicitly in the five-year plan, although they must clearly be paid for. Finally, this five-year plan includes no procurement of S-3A antisubmarine warfare aircraft.

THE IMPACT OF PRODUCTION RATES ON THE RATE OF EXPANSION

The condition of U.S. defense industries has been a matter of interest and concern over the past several years; at least one major Congressional hearing has been held on the subject. 4/ In particular, doubt has been expressed that ships, aircraft, and other items can be produced at the rates required to support the Navy's plan. The evidence suggests, however, that the Navy's plan can be implemented by continuing production of most types at rates that have prevailed in recent years while following new programs as planned. This is discussed in Appendix C.

4/ Capability of U.S. Defense Industrial Base, Hearings before the House Armed Services Committee, 97:1 (1980).

Further, according to data collected by the Naval Air System Command, much idle capacity now exists in companies that produce aircraft for the Navy. Most current aircraft types are being produced at below-capacity rates.

Indeed, problems in producing more weapons, if they occur at all, are more likely among the so-called "second tier" of manufacturers that produce electrical and other components for ships and aircraft rather than among the prime contractors that assemble the weapons. The current recession suggests that, in the near term, problems are unlikely even in this second tier of producers. But, as the economy recovers, bottlenecks could occur. Unfortunately, little data exist to predict precisely the scope of such bottlenecks. 5/

5/ For further discussion, see "Defense Spending and the Economy," statement of Alice M. Rivlin, Director, Congressional Budget Office, before the House Committee on Armed Services, February 1982.

CHAPTER III. ANALYSIS OF ALTERNATIVE APPROACHES TO MODERNIZING FIGHTER AND ATTACK FORCES

The preceding chapters have presented the rationale for and costs of the Navy's planned expansion and modernization of its carrier air forces. Much of the spending would be for expanding and modernizing the fighter and attack forces. This chapter analyzes in more detail the Navy plan for modernizing those forces and alternatives to that plan.

In 1981, the Navy revised its modernization plan by reducing the role of the F/A-18 as a carrier-based fighter in favor of F-14s on all large deck carriers, while reaffirming its choice of the F/A-18 as an attack aircraft. The Navy's goal of replacing the A-7Es and the remaining F-4s, could also be reached by equipping with F/A-18s all those fighter squadrons for which F-14s have not yet been procured, by equipping attack squadrons with something other than the F/A-18, or both. Because the F/A-18 is of central importance to any discussion of the Navy plan or alternatives, this chapter begins with a discussion of that program.

THE F/A-18 PROGRAM

The F/A-18 began as the F-18, originally conceived as a lower-cost complement to the F-14. It was based on the YF-17, which lost in the competition for the selection of the Air Force lightweight fighter, the F-16. The F-18 evolved into the F/A-18, an aircraft that can be used as either an attack aircraft (bomber) or a fighter by selecting the appropriate armament.

The Navy has had a continuing interest in a fighter/attack aircraft. Deploying a carrier with a pure fighter force, a pure attack force, and a "swing force" would add flexibility, since aircraft could be more efficiently allocated between the two missions in response to evolving circumstances. The Navy could use the fighter capability of the F/A-18s in attack squadrons to provide a short-range complement to the long-range capability of the F-14s in fleet air defense and to escort attack aircraft, freeing more F-14s for fleet air defense. Although it is acknowledged to be at least the equal of the F-14 as a dogfighter, the F/A-18 lacks the long-range weapon system that makes the F-14

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the Navy's preferred interceptor for fleet air defense. The argument for the F/A-18 as a fighter has always been primarily one of cost.

The program goal for the F/A-18 is 1,366 aircraft. This number was initially arrived at based upon a requirement to equip 24 Navy light-attack squadrons (two squadrons per carrier on each of 12 carriers), six Navy fighter squadrons (two squadrons per carrier on each of three carriers, the remainder having F-14s), and Marine Corps fighter and attack squadrons, as well as to supply some trainer and reconnaissance aircraft. During 1981, the Administration decided to procure the new version of the Harrier vertical take-off and landing aircraft (the AV-8B) for the Marine Corps attack aircraft, increase the number of Navy F/A-18 attack squadrons to 28, and eventually equip all Navy fighter squadrons with the F-14. 1/ This last step was justified on the ground that every carrier should have the superior air defense capability provided by two squadrons of F-14s. Nevertheless, the F/A-18 program goal remained at 1,366. Some F/A-18s may go directly to the reserves.

Description

The F/A-18 is a supersonic, twin-engine, single-seat aircraft that, when flown as a fighter, carries both the Sidewinder short-range air-to-air missile and the Sparrow medium-range air-to-air missile. Unlike some "fighter/bombers" that are produced in either a fighter or a ground attack configuration, the F/A-18 can perform either mission when given the appropriate weapon load. This characteristic makes it especially attractive to the Navy, which must fight with small numbers of aircraft at long distances from supply bases. In times of high air threat, a carrier could use its F/A-18 attack aircraft as fighters in fleet air defense or for escort of other attack aircraft, thus freeing more F-14s for fleet air defense.

1/ F/A-18s may be deployed in the fighter squadrons assigned to the Coral Sea and the Midway. However, if the Administration goal of F-14s on all the large deck carriers is to be realized, those F/A-18s will be replaced by F-14s when these carriers retire and their air wings are transferred to new Nimitz-class carriers.

The F/A-18 is generally considered to be equal to the F-14 in agility, although its maximum speed is lower. It is not equipped with either the long-range Phoenix air-to-air missile or a radar that is appropriate for the employment of the Phoenix.

In an attack mission, the F/A-18 would have a greater payload than the A-7E at short ranges, but a smaller payload at long ranges. The A-7E has become increasingly vulnerable to hostile action as the capabilities of Soviet systems have improved and as increases in its avionics and payloads have eroded its aerodynamic characteristics. It has lower speed, maneuverability, and thrust-to-weight ratio than the F/A-18.

In designing the F/A-18, the Navy has placed a premium on high reliability, availability, and maintainability (RAM). Low RAM has been a problem with many modern aircraft. It is of particular concern to the Navy because a carrier has limited aircraft assets, limited maintenance capability, and limited resupply capability at long distances. The Navy sees high RAM as one important advantage of the F/A-18 over the A-7E.

The F/A-18 is somewhat larger than the A-7E, which might mean that in the future a carrier would have two or three fewer airplanes than at present. 2/

Costs

The F/A-18 is not an inexpensive airplane, but it is not as costly relative to other aircraft as some of its critics maintain. Its costs are often compared unfavorably with those of the F-14. Unit costs for the F/A-18 over the life of the program are variously quoted at between $25 million and $40 million, in dollars adjusted for inflation up to the 1990s. Program unit costs for the F-14 are said to be $20 million to $25 million, in dollars spent during the 1970s. F/A-18s procured in fiscal year 1982 cost $38 million each (in then year dollars) including initial spare parts, while F-14s procured in 1982 cost about $39 million each with initial spare parts. But this is not the most

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2/ The installation of the Tactical Airborne Reconnaissance Pod System on three F-14s in each wing will permit the retirement of the three RF-8 reconnaissance aircraft currently carried, making more space available.

relevant basis for comparison. The F-14 is nearing completion of its original procurement program, so that the Navy is now buying the least expensive units (in constant dollars), while procurement of the F/A-18 is just beginning. The F/A-18s remaining to be bought will average $20.0 million each in 1983 dollars ($21.1 million if the 1982 buy is included), with unit costs decreasing as time goes on. 3/ Therefore, despite perceptions to the contrary, the F/A-18 will be substantially less costly than the F-14 if the program outlined in the Selected Acquisition Report (SAR) is actually followed. On the other hand, the F/A-18 is more costly than comparable attack aircraft. The A-7E costs only about $11 million in 1983 dollars. The A-6E medium attack aircraft currently costs about $27 million, but is being procured at an inefficient rate.

Finally, the Navy has already made a substantial investment in the F/A-18. By the end of 1982, 34 percent of the currently estimated cost (in constant dollars) of the total program will have been spent, and 157 production aircraft and 11 research and development (R&D) aircraft will have been procured.

ALTERNATIVE ATTACK AIRCRAFT

This section examines four alternative forces for replacing the Navy's light-attack squadrons.

Option 1: The Navy's Preferred Force

- 24 F/A-18s per air wing;
- Total cost of $12.1-13.3 billion in 1983 dollars.

Option 2: Current Force of A-7Es

- 24 A-7Es per air wing, replacing old A-7Es as they retire with new A-7Es;
- Total cost of $5.5-7.6 billion in 1983 dollars.

3/ This is based upon the program in the Defense Department's December 1981 F/A-18 Selected Acquisition Report (SAR). Reducing procurement rates from those upon which the SAR is based would increase unit costs.

Option 3: Re-engined A-7 Force

- o 24 A-7Xs per air wing;
- o Total cost of $8.2-10.3 billion in 1983 dollars.

Option 4: All A-6E Force

- o 20 additional A-6Es per air wing;
- o Total cost of $8.8-12.5 billion in 1983 dollars.

Aircraft Description

The A-7E. The A-7E entered the fleet in 1970. It is a single-seat, single-engine, subsonic aircraft designed to complement the A-6E. The A-7E does not have the A-6E's mission of attacking targets totally obscured by darkness or weather. It has less range and a smaller payload than the A-6E, but it costs less and requires less space on the carrier per aircraft.

The A-7X. Vought Corporation, the manufacturer of the A-7E, has designed two new A-7 models which it designates A-7X. The A-7X is not part of the official Navy program, and no prototype of it exists. Since it represents a combination of an existing airframe and an existing engine, it is somewhat more than a "paper airplane." It is not likely that the A-7X could go into production for several years, however. Of the two A-7X models, the one considered here is a supersonic aircraft with a thrust-to-weight ratio and other aerodynamic characteristics somewhat similar to those of the F/A-18.

While Vought does not claim that the A-7X would have all the capability of the F/A-18 as a fighter, it would have some, especially in the escort mission. It could evade or engage when attacked considerably better than the A-7E does. The A-7 airframe is based upon that of the F-8, a Vietnam-era fighter. As an attack aircraft, the A-7X could carry a somewhat greater payload than the A-7E, but less at short ranges than the F/A-18. It would be roughly the same size as the A-7E. Like the A-7E, it is a single-seat airplane.

The A-6E. The A-6E now in Navy medium-attack squadrons enables the Navy to attack targets in "all weather" conditions and at greater ranges than those to which light-attack aircraft

can fly, and has a substantial payload advantage over light-attack aircraft at longer ranges. It carries a crew of two and is substantially larger than the A-7E.

Estimating the Capability of Alternative Forces

The mission of attack aircraft is to attack targets ashore and afloat with bombs and guided missiles. The primary measure of effectiveness of an attack force is the number of pounds of ordnance it is capable of delivering to a target area during an operating period. This section presents the results of a calculation of the number of pounds of bombs that could be delivered to a target area in the course of a single 12-hour operating day by each of the four alternative forces of attack aircraft operating in conjunction with the one medium-attack squadron on the carrier. It takes the following factors into account: aircraft range and payload characteristics; the rate at which a carrier can launch, recover, and service aircraft; and mission availability rates. A constant fraction of the launches are of aircraft other than attack aircraft. This only affects the calculated capacity at short ranges; at other ranges, there are not enough attack aircraft available to fill all the launch slots allotted to them. The calculation assumes a "high-low-high mission" profile. 4/ The calculation is described in more detail in Appendix A.

Findings. The results of the calculation for the four alternative forces are shown in Figure 1 as a function of range to target. Figure 2 presents the same results in a different way--as the capabilities of each of the alternatives relative to the Navy's preferred force.

The capability of all four forces drops off rapidly as range increases, especially between 250 and 350 nautical miles. All forces deliver large quantities of bombs at short ranges, while none of the forces performs well in absolute terms at very long ranges.

In general, at ranges up to 300 nautical miles the Navy's preferred force performs better than the other three forces, but

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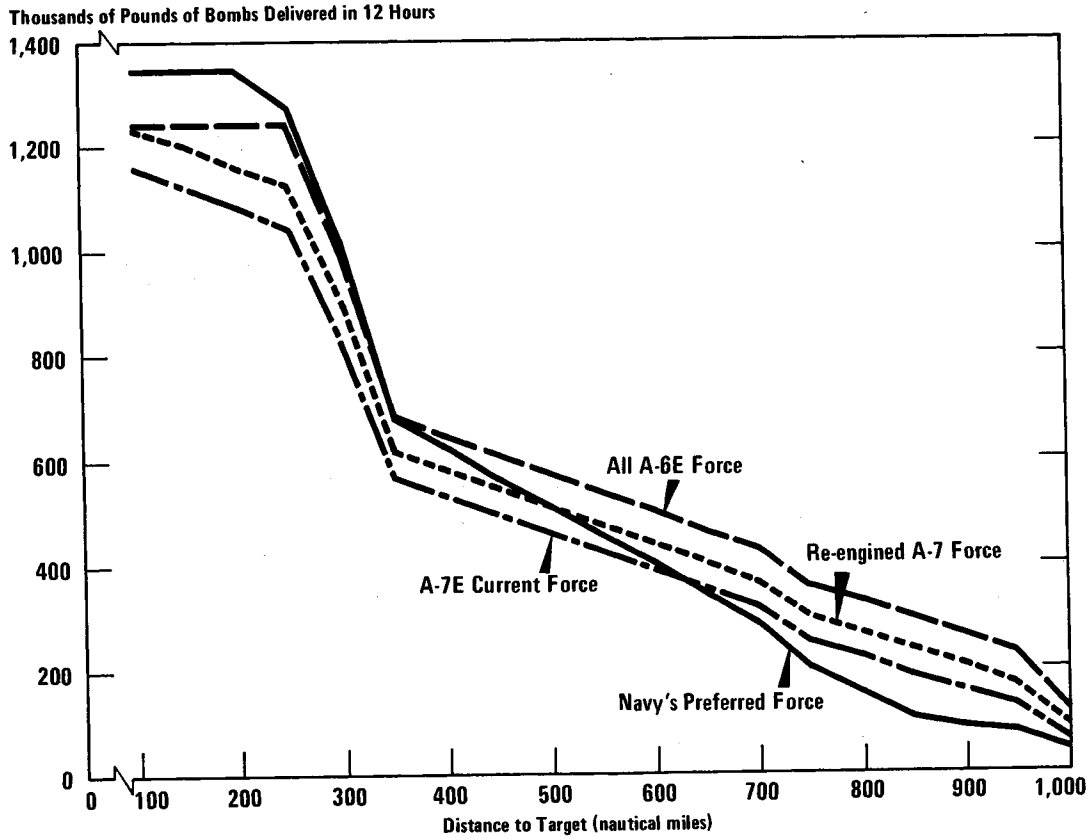
4/ In a high-low-high mission, the airplane flies to the vicinity of the target at high altitude, descends to attack, and climbs to cruising altitude for its return to the carrier.

Figure 1.

Capabilities of Alternative Attack Forces

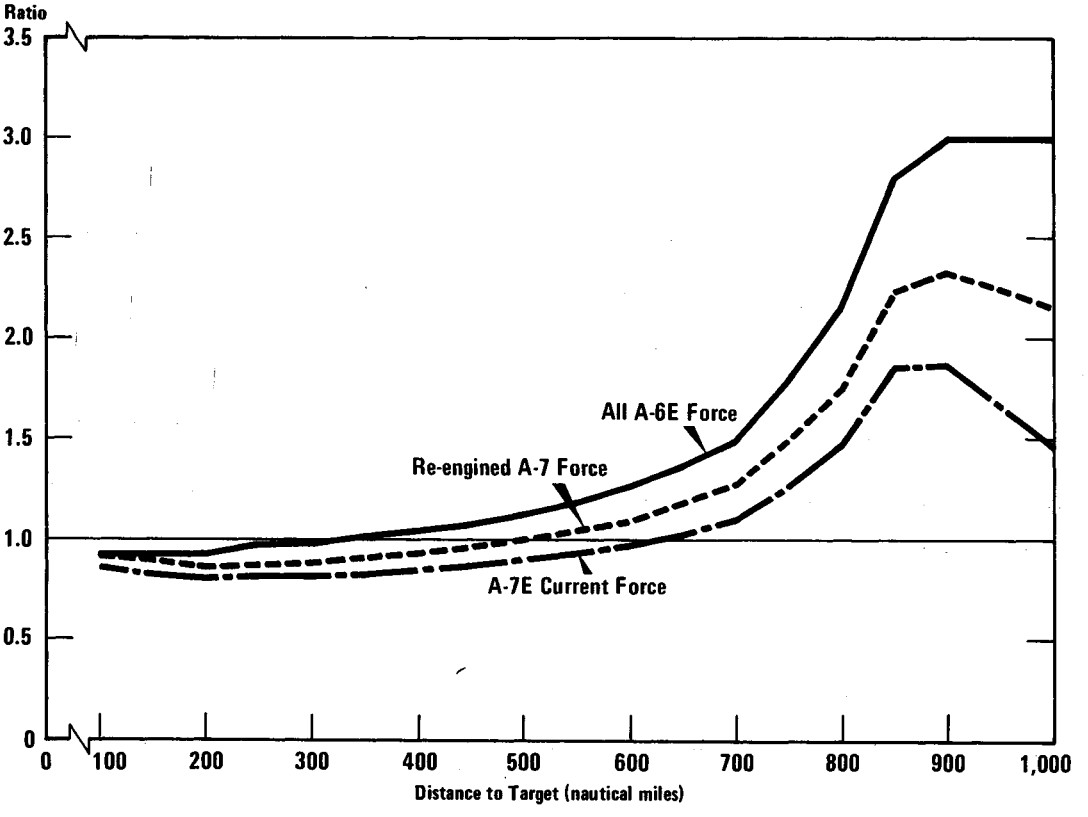


not by a wide relative margin. At ranges beyond 600 nautical miles, the three alternatives become much more capable than the Navy's mix, and they display substantial relative advantages over the Navy's mix beyond 800 nautical miles. From 300 to 600 nautical miles, the A-7X force is about equal in capability, on the average, to the F/A-18 force; the A-7E force is less capable; and the all A-6E force is more capable.

This calculation is in terms of the total ordnance delivery capacity of an attack force. The total capacity may not always be used, due to operational constraints, especially at short range.

Figure 2.

Ratios of Bomb Delivery Capacities of Alternative Forces to That of Navy's Preferred Force



However, a force with a higher delivery capacity can accomplish the same mission with fewer sorties than a force with a lower delivery capacity, freeing carrier launch slots for other missions such as fleet air defense or antisubmarine warfare.

The best case for the F/A-18 is made at short ranges, but differences among the alternatives are not great at these ranges. While the Navy has preferred to operate at ranges of 100 to 300 nautical miles, actual combat may involve greater distances. When attacking targets ashore, natural hazards or the presence of coastal defense craft could dictate perhaps 100 to 300

miles of stand-off from shore. In addition, not all targets will be directly on the coast, so that distance inland will have to be added to that from shore. Moreover, antiship cruise missiles and the development of Soviet ships operating aircraft will increasingly require stand-off of a few hundred miles when attacking Soviet naval forces.

Carriers will not be able to operate sufficiently far from shore to avoid attack by long-range Soviet bombers such as the Backfire, which have much greater range than all carrier aircraft. They might well operate beyond the normal operating ranges of shorter-range Soviet attack aircraft and beyond the ranges to which Soviet fighters could accompany bombers. The Soviet aircraft available for attacking carriers and other ships are the Su-17 Fitter D and H with a range of 475 nautical miles, the MiG-27 Flogger D and J with a range of 550 nautical miles, and the Su-24 Fencer A with a range of 975 nautical miles. 5/ Avoiding those aircraft would require stand-off distances at least equal to their ranges. Seven different Soviet fighters have ranges of 475 to 775 nautical miles. A carrier would have to operate about 100 nautical miles beyond the ranges of these fighters in order for the F-14s to be able to intercept a bomber after it has left the protection of its fighters and before it can launch a missile at the carrier. If the bases from which these Soviet aircraft operated were between the carrier and its target area, the range to which the carrier attack force would have to fly would be even greater.

At the longest ranges (800-1,000 nautical miles) the three alternatives, and especially the A-6E, have greater capability than the F/A-18. While naval aircraft cannot mount a very large attack at such ranges, the capability to attack at long range may be necessary if the Navy wants to be able to attack Soviet bases, particularly in the initial period of combat.

At middle ranges of 300 to 600 nautical miles, the all A-6E force has superior capability to the Navy's preferred mix, the A-7X force has about the same capability, and the A-7E has less capability.

Factors Not Included. The calculation does not include all the factors affecting capability. Some, like accuracy of

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5/ This range information is obtained from Department of Defense, Soviet Military Power.

bomb delivery, would not alter the results in any significant way. Others, like the ability of the F/A-18 to perform fighter missions have no effect on these results but could prove important in certain scenarios. Still other factors cannot easily be quantified, but need to be included in any comparison of attack aircraft.

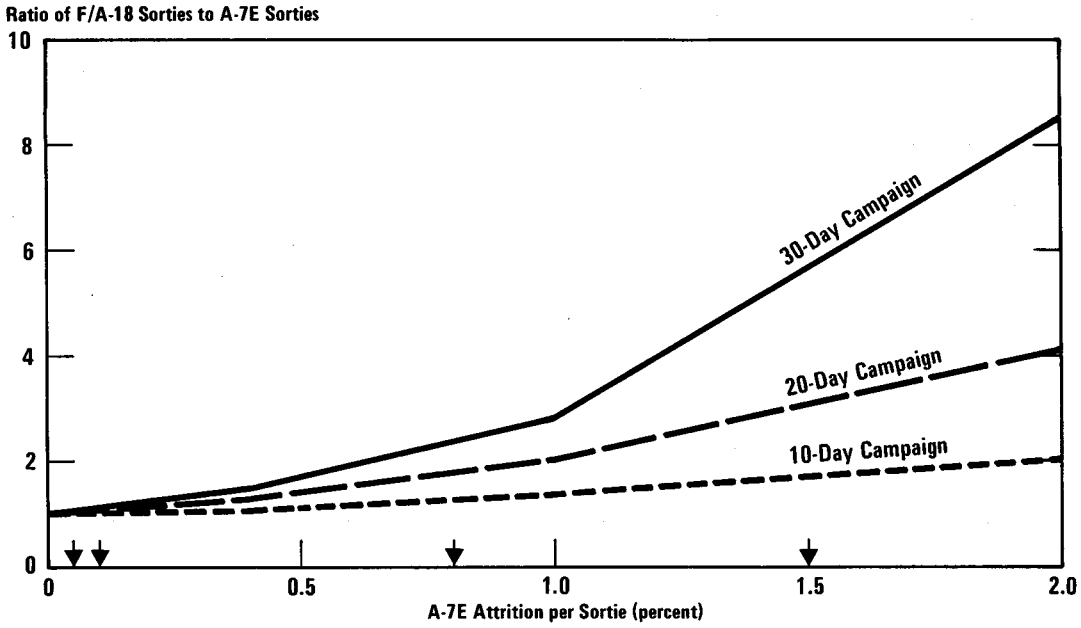
Accuracy of Delivery. This model has not included the accuracy with which an airplane delivers bombs to a target. All these airplanes can launch guided missiles, the accuracy of which is basically independent of aircraft characteristics. All carry similar devices--radars and Forward Looking Infrared systems and fire control computers--for locating targets and determining launch points for gravity bombs. The A-7E and A-6E have similar accuracy for the release of bombs, and it is anticipated that the F/A-18 will, and the A-7X could, have the same accuracy. However, the A-6E has the advantage of a two-man crew, which permits more attention to be paid to those functions associated with the delivery of weapons. It is the Navy's all-weather, day/night attack bomber "equipped specifically to deliver . . . weapons on targets completely obscured by weather or darkness." 6/ Thus, there are conditions under which the A-6E could operate, while the others could not. This difference, although not easily quantifiable, should be taken into account.

Attrition Rates. Attrition due to enemy action has also not been taken into account. Inclusion of reasonable average wartime attrition rates would alter the total weight of bombs delivered in a single day by only about 1 percent. Over several days or weeks, however, relatively small attrition rates could have large consequences. For example, at 3 percent attrition per day, 40 percent of a force would remain after 30 days. At 1 percent, 74 percent, or nearly twice as much, would remain. Higher attrition not only means higher replacement rates, it also means fewer sorties for carrier-based aircraft that cannot be replaced. A force sustaining 1 percent attrition would fly roughly twice as many sorties in 30 days as one sustaining 3 percent attrition. To the extent that the F/A-18 is more survivable than the A-7E, it could be much more effective over an extended battle. How much more effective depends upon the length of the battle and the difference in attrition rates. No attempt has been made to predict what these factors might be, but their effect can be demonstrated by a parametric treatment.

6/ Jane's All the World's Aircraft, 1980-81.

Figure 3.

How a Three-to-One Advantage in Attrition Rates Would Affect the Ratio of Sorties by F/A-18s to Sorties by A-7Es Over the Course of a Campaign



NOTE: The aircraft are assumed to make five sorties per day. The range of attrition rates shown on the horizontal scale may be compared with historical rates of 1.5 percent per sortie for Israeli A-4s in the Yom Kippur War (1973), 0.8 percent for all Israeli aircraft in the same war, 0.1 percent for U.S. Navy aircraft over North Vietnam (1965-1973), and 0.05 percent for Navy aircraft over all of Southeast Asia (1965-1973).

The importance of different attrition rates can be illustrated. An earlier Congressional Budget Office report compared the A-7E and the F/A-18, partially on the basis of relative attrition rates. 7/ That report employed a Navy estimate that A-7E attrition would be about three times F/A-18 attrition. Using that assumption, Figure 3 shows how the ratio of sorties generated by a force of F/A-18s to sorties generated by an equal number of

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7/ Congressional Budget Office, Navy Budget Issues for Fiscal Year 1980 (March 1979).

A-7Es would increase over the course of a campaign, assuming five launch cycles per day and assuming that no new aircraft replaced those lost by the carrier. Clearly, under certain circumstances, a factor-of-three improvement in survivability could, if realized, be very important. It must be stressed, however, that absolute attrition rates, relative attrition rates, and length of campaign are "soft" numbers that lack the accuracy of factors such as ranges and payloads.

Reliability and Maintainability. The calculation presented in Figures 1 and 2 considers only a single day, during which differences in operational readiness, mean time to fail, and mean time to repair (as well as combat attrition) would have a relatively minor effect. Thus the calculation may ignore a large advantage of the F/A-18, if the Navy's investment in reliability and maintainability proves effective.

Refueling. All of these airplanes can be refueled in flight, extending their ranges. If refueling were included in the calculation, it would increase the capabilities of all four forces, but would not alter the relative differences among them.

Newer Technology. The F/A-18 is a much newer airplane, technologically, than the others. New techniques have been incorporated to aid the pilot in operating the airplane and its weapon systems. The effect of this on operational capabilities is difficult to quantify plausibly.

Multimission Capability. A major characteristic of the F/A-18 that is not captured in the analysis and is difficult to quantify is the ability of the airplane to fly either fighter or attack missions on short notice. It has a radar for air combat and can carry Sidewinder and Sparrow missiles. F/A-18s placed in attack squadrons could also be used to augment fighters in fleet air defense, or to escort attack planes and thus free fighters for fleet air defense. F/A-18s flying attack missions (and properly armed) would have a reasonable chance of escaping from, or successfully engaging, enemy fighters. The A-6E and the A-7E would be no real match for a fighter because they are relatively poor in acceleration and maneuvering and their radar is inadequate for air combat, although they carry Sidewinder missiles for self-protection. The A-7X, if developed as advertised, could have some or many of the fighter capabilities of an F/A-18. With the appropriate radar, it could operate the Sparrow missile. How important one considers this multimission capability to be depends upon a judgment as to the adequacy of carrier fighter forces. If

fighter forces are insufficient, augmentation would be useful. If current fighter forces are much more than adequate, the ability to augment them would be of marginal utility. Scenarios in which more fighters are needed can always be created. The value of the F/A-18 multimission capability will ultimately turn upon how plausible (and likely) those scenarios are believed to be, and how much the Navy and the Congress are willing to pay for the capability.

Costs of Alternative Forces

Long-Run Procurement Costs. The costs of procuring enough aircraft to equip 28 squadrons (14 carrier air wings) are shown in Table 6, for each of the four alternatives.

The cost of the F/A-18s is the cost of the last 693 aircraft in the current program. This is the cost that would be avoided if some other option were chosen. In Chapter II, F/A-18s were costed at the average unit cost for the entire program (excluding those already procured). The range of costs shown in the table for the F/A-18 results from different assumptions regarding the distribution of support costs within the program.

TABLE 6. PROCUREMENT COSTS OF ALTERNATIVE ATTACK AIRCRAFT FORCES

Option	Aircraft	Number Procured a/	Total Cost (billions of 1983 dollars)
Navy Preferred	F/A-18	693	12.1 - 13.3
Current Force	A-7E	700	5.5 - 7.6
Re-engined A-7s	A-7X	700	8.2 - 10.3
All A-6Es	A-6E	583	8.8 - 12.5

a/ Includes aircraft for carrier squadrons, for training, for repair pipeline, and for 15 years' estimated attrition.

The ranges of costs presented for the A-7E and A-7X arise from differences between contractor estimates and estimates using assumptions generated by the Navy. Compared with the Navy's preferred option, the current force option would save $4.5 billion to $7.8 billion. The re-engined A-7 option would save $1.8 billion to $5.1 billion.

The range of costs for the all A-6E option stems from a somewhat different source. These aircraft are currently being procured at a rate of 8 to 12 per year. In order to produce 583 additional A-6Es in a reasonable period of time, the rate would have to be accelerated to about 96 per year. Two models have been developed for predicting unit costs when the yearly buy rate changes, but few data exist upon which to base a projection for such a large change in the buy rate. 8/ Using one model and various assumptions (including those provided by the manufacturer) produces costs that range from $8.8 billion to $10.0 billion. Using the other model produces costs of $11.2 billion to $12.5 billion. The procedure is discussed more fully in Appendix B. The A-6E option could thus be as much as $4.5 billion less costly than the F/A-18 or $0.4 billion more costly.

Life-Cycle Costs. The cost comparisons in Table 6 show the differences among the four options in the cost of procuring the aircraft required to establish the squadrons and operate them for 15 years. They do not capture all the cost differences associated with owning and operating these forces. In particular, there are differences in yearly operating costs. The aircraft also have different service lives, which means that the value of the aircraft remaining after 15 years would differ from type to type. An F/A-18 would reach the end of its service life in 15 years and would have to be replaced, whereas an A-6E with a service life of 23 years would have eight years of service left after 15 years. Table 7 shows the total 15-year cost of each of the alternatives (not including the 10 A-6Es common to all alternatives). The "procurement" cost shown is obtained by calculating a procurement

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8/ See the descriptions by Commander Steve J. Balut, "Three Views of the Impact of Production Rate Changes: I. Redistributing Fixed Overhead Costs," Concepts: The Journal of Defense Systems Acquisition Management, vol. 4 (Spring 1981), pp. 63-76; and John C. Bemis, "Three Views of the Impact of Production Rate Changes: III. A Model for Examining the Cost Implications of Production Rate," Concepts, pp. 84-94.

TABLE 7. FIFTEEN-YEAR TOTAL COSTS OF ALTERNATIVE ATTACK AIRCRAFT FORCES

Option	Aircraft	Service Life (years) a/	Procurement (billions of 1983 dollars) b/	Yearly Operation (millions of 1983 dollars per aircraft) c/	Total 15-Year Cost (billions of 1983 dollars) d/
Navy Preferred	F/A-18	15	12.1-13.3	2.22	26.1-27.3
Current Force	A-7E	17	5.1-7.0	1.74	16.1-18.0
Re-engined A-7s	A-7X	13 e/	8.5-11.4	1.91 e/	20.5-23.4
All A-6Es	A-6E	23	6.4-9.0	2.86	21.4-24.1

a/ Supplied by the Navy, except for A-7X.

b/ That part of procurement including attrition aircraft that would be incurred in 15 years if the procurement costs were evenly spread over the full service life of the aircraft.

c/ Supplied by the Navy, except for A-7X; includes personnel.

d/ Covering operation of active aircraft and training aircraft, plus procurement.

e/ Based on manufacturer's comparison of A-7E and A-7X service hours.

cost that includes attrition aircraft for the full service life, and then scaling that total cost by the ratio of 15 years to the full service life.

When looked at this way, the Navy's preferred option is most costly; the all A-6E option and the re-engined A-7 option are about equal in cost; and the current force option is the least costly.

Five-Year Procurement Costs. While the differences in long-run costs could be substantial, over the next five years differences would be minimal. Accordingly, no estimates are presented.

Meaningful five-year costs would be difficult to define for the Navy's preferred option. The F/A-18 aircraft for the attack squadrons would be produced concurrently with other F/A-18 aircraft and would be indistinguishable from the others in the absence of a list specifying in advance the assignment of individual units. With such a breakdown, costs could be listed by year. While this could be viewed as a true accounting of the costs, it is not a meaningful one for comparing options, since it is not a measure of the costs that would be avoided were this option not chosen. These latter costs, which are shown in Table 6, are obtained by eliminating aircraft from the end of the program.

If another airplane is chosen in place of the F/A-18 as the Navy's replacement for the A-7E, one of three basic strategies could be followed in procuring it. The first would be to begin procurement as soon as possible--that is, during the 1980s concurrently with the F/A-18s that are being procured for other roles. Assuming the F/A-18 program followed the current production schedule, but ended much earlier than it otherwise would, the defense budget would be increased for several years while both aircraft were in production.

A second strategy would be to divide the procurement dollars that would otherwise fund only the F/A-18 program between the two airplanes, lowering yearly buy rates and stretching out both programs. This would reduce the impact on the budget in any given year, but would force higher unit costs of both aircraft and hence higher total costs. Both of these strategies would, however, introduce the new attack airplane into the fleet at the earliest possible date, probably about 1986. (Since the A-6E is currently in production at a low rate, its introduction could begin somewhat earlier.)

A third strategy would be to delay procurement of the new attack aircraft until the reduced F/A-18 buy was completed. If 673 F/A-18s were procured rather than the 1,366 currently in the program, the F/A-18 buy would be completed about 1987, assuming the currently planned production rate schedule is followed. Procurement of the alternative attack aircraft could begin about 1986, with the first units entering the fleet possibly in 1989. This strategy would avoid unit cost increases associated with stretching out a program.

Of the three strategies, the third has the advantages of not increasing the defense budget over the next five years and of not increasing the cost of the alternatives by stretching out

programs. It would also have the lowest cost impact over the next five years. In this case, the four alternatives would show the same yearly costs for 1983 to 1985, a slight difference in 1986, and a real difference only in 1987 and beyond. This approach would, however, delay the modernization of the Navy's attack force. The new A-7Es, A-7Xs, or A-6Es would begin entering the fleet about 1988, and the last units would reach the fleet about 1993. By contrast, under the current procurement program, the F/A-18 could enter attack squadrons in 1983 or 1984, and the last units would probably be available by about 1990.

Summary of Attack Aircraft Options

The primary measure of the effectiveness of an attack force is the number of pounds of ordnance it can deliver to a target area during an operating period. Other important considerations are how survivable it is in a hostile environment and how reliable and maintainable the aircraft are, since these factors affect the long-term capacity of the force for ordnance delivery.

Navy Preferred Force. The Navy's preferred force would have a capacity to deliver bombs (measured in pounds delivered in a day) about 20 percent greater than that of the current force, at ranges up to 500 nautical miles from the carrier. 9/ This advantage takes into account superior reliability and maintainability resulting in an initial availability rate one-fourth again as great as those of the A-6E or A-7E. The Navy has operated at these ranges in the past. There is a strong incentive to continue to do so since, regardless of the composition of the attack force, the number of pounds of bombs delivered decreases rapidly as the range of the target from the carrier increases.

Greater stand-off ranges may, however, be required as Soviet capabilities improve, especially in land-based aircraft and missile-equipped coastal craft. In particular, attacks on heavily defended Soviet naval facilities can be expected to encounter significant resistance the closer they get. 10/ Should the Navy

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9/ Much of the advantage would be subject to constraints imposed by the rate at which bombs can be loaded on aircraft.

10/ The Navy has argued that by such attacks it could attempt to deny Soviet forces the ability to put to sea in order to harass the sea lanes.

be forced to operate at long ranges, its preferred force would be less capable than the current force. In particular, beyond 800 miles the F/A-18s would have no capability at all without refueling, so that only the A-6Es in the force could deliver ordnance. At these ranges, the Navy's preferred force would be about 60 percent as capable as the current force.

To the extent that F/A-18 wartime attrition, failure, and repair rates proved better than those of the other alternatives, the capability of the Navy's preferred force would be progressively enhanced relative to the others as the length of an engagement increased. This could be the dominating consideration if the differences were large enough and the engagement long enough. The advantage will be of little value, however, if operations are conducted at long ranges where the F/A-18s cannot operate.

The Navy's preferred force has the added advantage that F/A-18s can be flown as fighters. If they were used to escort an attack, they could free F-14s for fleet air defense; alternatively, they could augment F-14s in fleet air defense.

A-7E Current Force. The A-7E option would continue the current attack force of A-6Es and A-7Es by replacing the A-7Es as they retire with new A-7Es. In February 1982, the Chief of Naval Operations called the A-6E and A-7E "the most capable attack aircraft in the world today, night and all-weather included." 11/ The Navy's concern is that the relatively sluggish A-7E would be subject to unacceptable losses from modern Soviet fighters. This option would cost $4.5 billion to $7.8 billion less than the Navy's preferred option.

Re-engined A-7 Force. The re-engined A-7 option provides a somewhat different approach to the vulnerability problem. The A-7X is a design by Vought Corporation, which manufactures the A-7E. It would re-engine the A-7E to make it supersonic and give it other aerodynamic characteristics, especially thrust-to-weight ratio, somewhat similar to those of the F/A-18. Doing so would, in Vought's view, provide an aircraft about as survivable in a hostile environment as the F/A-18. Moreover, buying the A-7X rather than the F/A-18 would save $1.8 billion to $5.1 billion. However, while the other alternative forces are composed of

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11/ Statement to the House Committee on Armed Services, February 8, 1982.

existing aircraft, the A-7X exists on paper only, although it is a marriage of an existing airframe and an existing engine.

At target ranges of less than 400 nautical miles, the re-engined A-7 option would be about 10 percent less capable than the Navy's preferred option. At longer ranges, it would be up to 2.3 times more capable. Compared with the current force, it would be about 15 percent more capable at all ranges.

All A-6E Force. The all A-6E force would provide the air wings with a homogeneous force of aircraft able to carry much greater payloads to longer ranges than any light-attack aircraft, and able to attack targets obscured by weather or darkness. Since the A-6E is much larger than the A-7E, only ten are in each squadron. The all A-6E force would be more capable than the Navy's preferred force at ranges beyond 300 nautical miles, and slightly less capable at shorter ranges. Beyond 800 nautical miles, it would be three times as capable as the Navy's preferred option, twice as capable as the current force. Procuring the all A-6E force would not, however, solve the vulnerability problem.

The procurement cost of this alternative could be as much as $4.5 billion less than the Navy's preferred alternative, or could be slightly higher. The 15-year life-cycle costs would be lower. This range of costs arises primarily from the application of two different methodologies to estimate the unit cost at yearly procurement rates about ten times those of recent years. Several estimates using one methodology are clustered near the lower overall cost, while several others are clustered near the higher estimates.

Delivery Schedules. If the Navy's preferred force is procured, attack aircraft deliveries could begin in 1983 or 1984 and be completed in the early 1990s. If another option is chosen, delivery within the same span would require increasing budgets in the next few years. Otherwise, deliveries would begin about 1988 or 1989 and end in the mid-1990s. If the F/A-18 is procured as the Navy's fighter rather than the F-14, money could be available to fund an attack aircraft beginning in 1983 or 1984.

ALTERNATIVE FIGHTER AIRCRAFT

The Navy intends to meet its requirements for ten additional fighter squadrons--four to equip the two expansion wings and six to replace the remaining F-4s--by purchasing more F-14s. Earlier

the Navy had planned to use the F/A-18 to fill out its fighter force. Substantial amounts could be saved by returning to this earlier Navy plan.

To do so would mean adding less capable fighters to the remainder of the fleet. In the most important mission--that of defending the carrier from incoming missiles--the F-14 is acknowledged to be superior. But the F/A-18 would be much less costly, both over the next five years and in the long run, and it would be the equal of the F-14 in battle with enemy fighters.

Fighter Capabilities

Navy fighters fly two major missions: fleet air defense, and the escort of attack aircraft. The latter mission involves air combat with enemy fighters. The F-14 and F/A-18 appear to be reasonably similar in those attributes affecting air combat. Some analysts believe that the greater maneuverability and smaller size of the F/A-18 may even make it superior to the F-14 against enemy fighters. 12/

The F-14, with its Phoenix missile, was designed to intercept enemy aircraft in fleet air defense. In this it is superior in several ways to the F/A-18. In fleet air defense, a fighter is vectored toward an enemy aircraft that is traveling in the direction of the carrier battle group. The fighter attempts to engage the enemy bomber before it can launch a missile at a ship. 13/ The success of the intercept is critically dependent upon the time required from detection of the incoming bomber (usually by an E-2 airborne early-warning aircraft) until the fighter's weapons destroy it. More than one enemy aircraft would be likely to attack a carrier, and several interceptors would be involved

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12/ Congressional Research Service, Fighter Aircraft Program: F/A-18, Issue Brief 78087 (March 1981); Congressional Research Service, Fighter Aircraft Program: F-14, Issue Brief 76056 (March 1981, and Congressional Research Service, The F/A-18 Hornet: Background Analysis of the Navy/Marine Corps F/A-18 Fighter/Attack Aircraft Program, Report 78-224-F (December 1978).

13/ Typically at about 100 nautical miles from the carrier. See Jane's Weapon Systems, 1980-81.